Reaction to fire of glass/ hemp/ furan composites

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Reaction to fire of glass/ hemp/ furan composites

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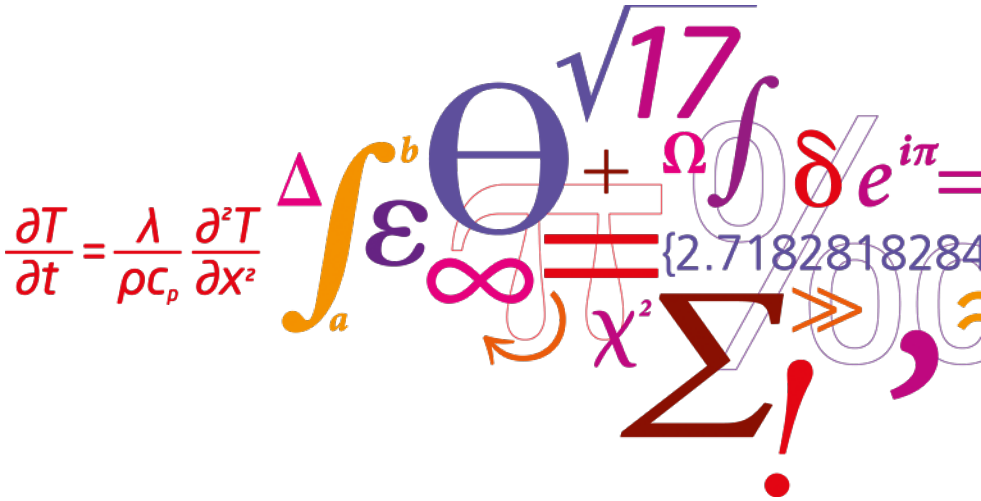


DTU Civil Engineering
Department of Civil Engineering

Scope of the presentation

- Furfuryl alcohol is used for wood coatings and many other purposes in industries
- The paper is investigating the reaction to fire for composites using:
  - resin of furfuryl alcohol & glass fibers or hemp fibers.
- The composites are made at DTU wind energy using a compression moulding technique
- The samples used for the fire tests had been stored for some years under ambient conditions inside a laboratory environment.
- TGA results are reported and compared to literature data

Production path of the PFA resin

Sugar cane

or

agricultural wastes

Sugar extraction

BAGASSE

Lignin, Cellulose

Hemicellulose

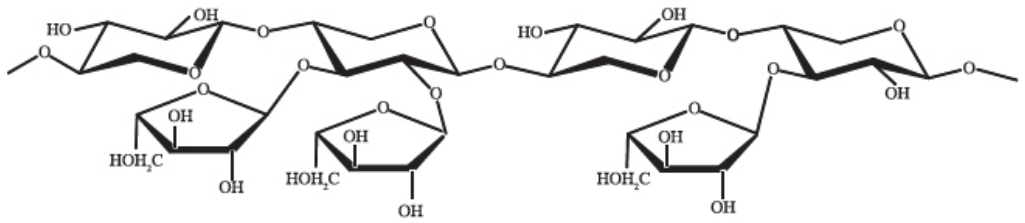
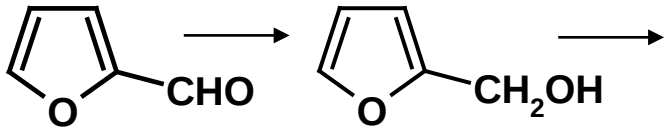


Figure 5. Example of hemicellulose structure: L-arabino-D-xylane according to Ebringerova et al.[44]

Hemicellulose



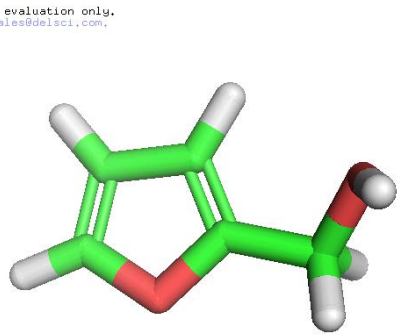
Furfural *Furfuryl alcohol*

Oligomerisation

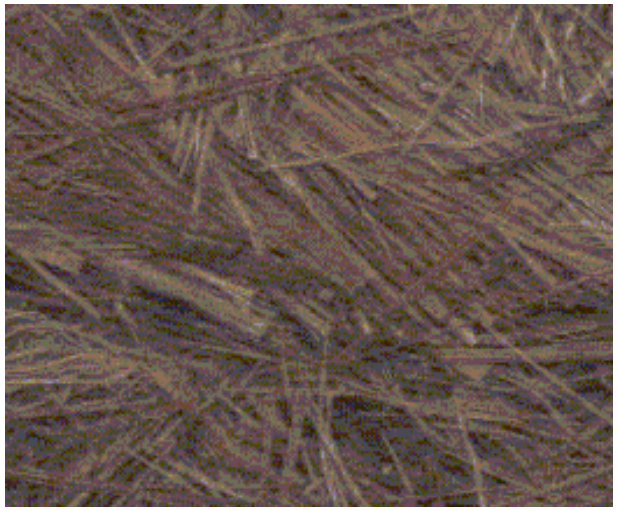
Source:TransFurans Chemicals (TFC)

Furfuryl alcohol

- **Thermoset composites using renewable resources:**
  - **Furanic resins**
  - **Possible fibres:**
    - **Hemp**
    - **Flax**
    - **Wood**
    - **Glass**
    - **…**



Furfuryl alcohol



Production of (bio-)composites

- Composites made of glass or hemp fibers and furfuryl-alcohol are an alternative for fossil fuel based conventional materials

- Such composites have excellent strength and furfuryl alcohol is manufactured from agricultural residues

- In general, many different sustainable bio-composites are developed in many different areas as they are seen as excellent alternatives to conventional materials with regard to their weight-strength ratio.

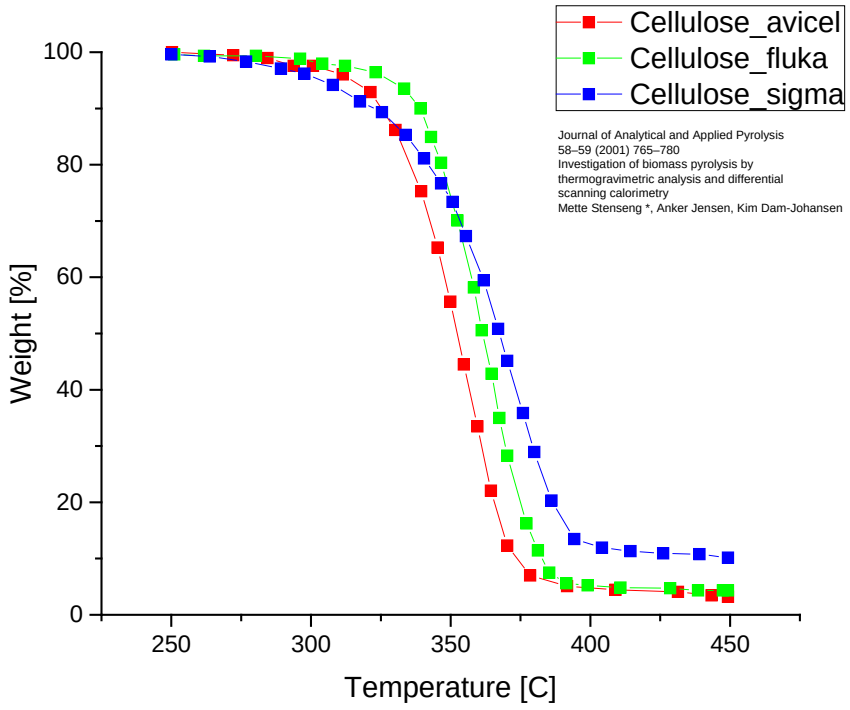
Reaction to fire

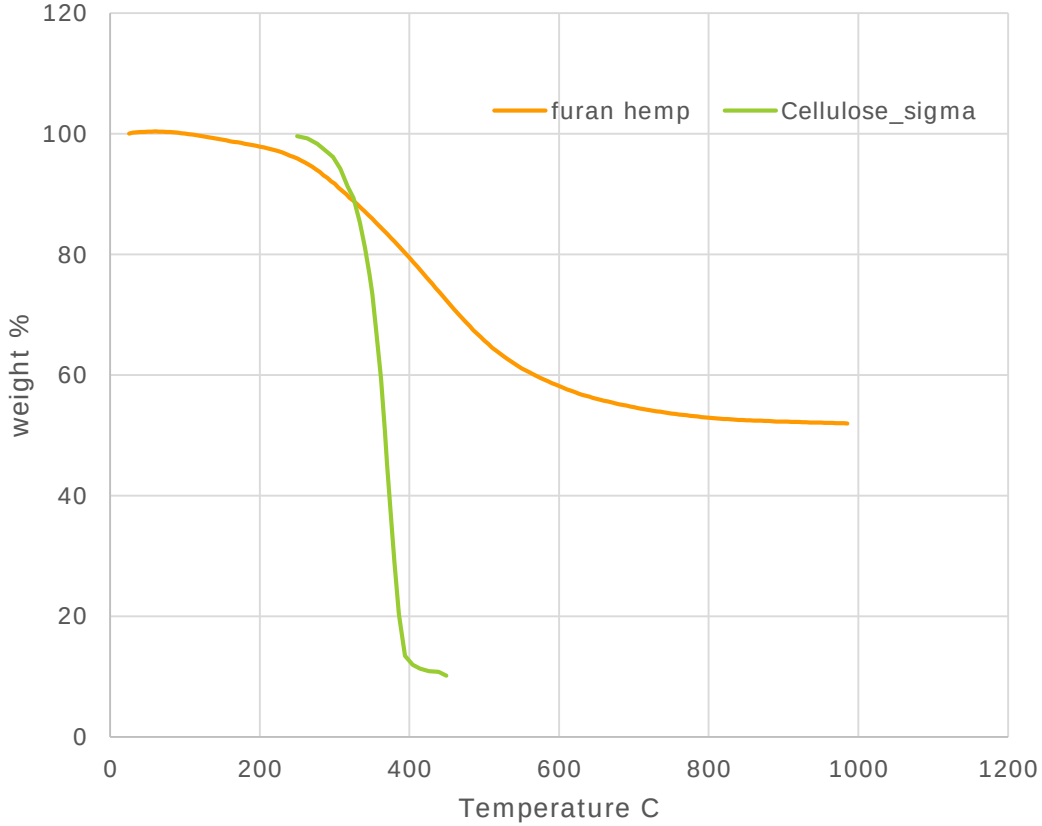
before

after

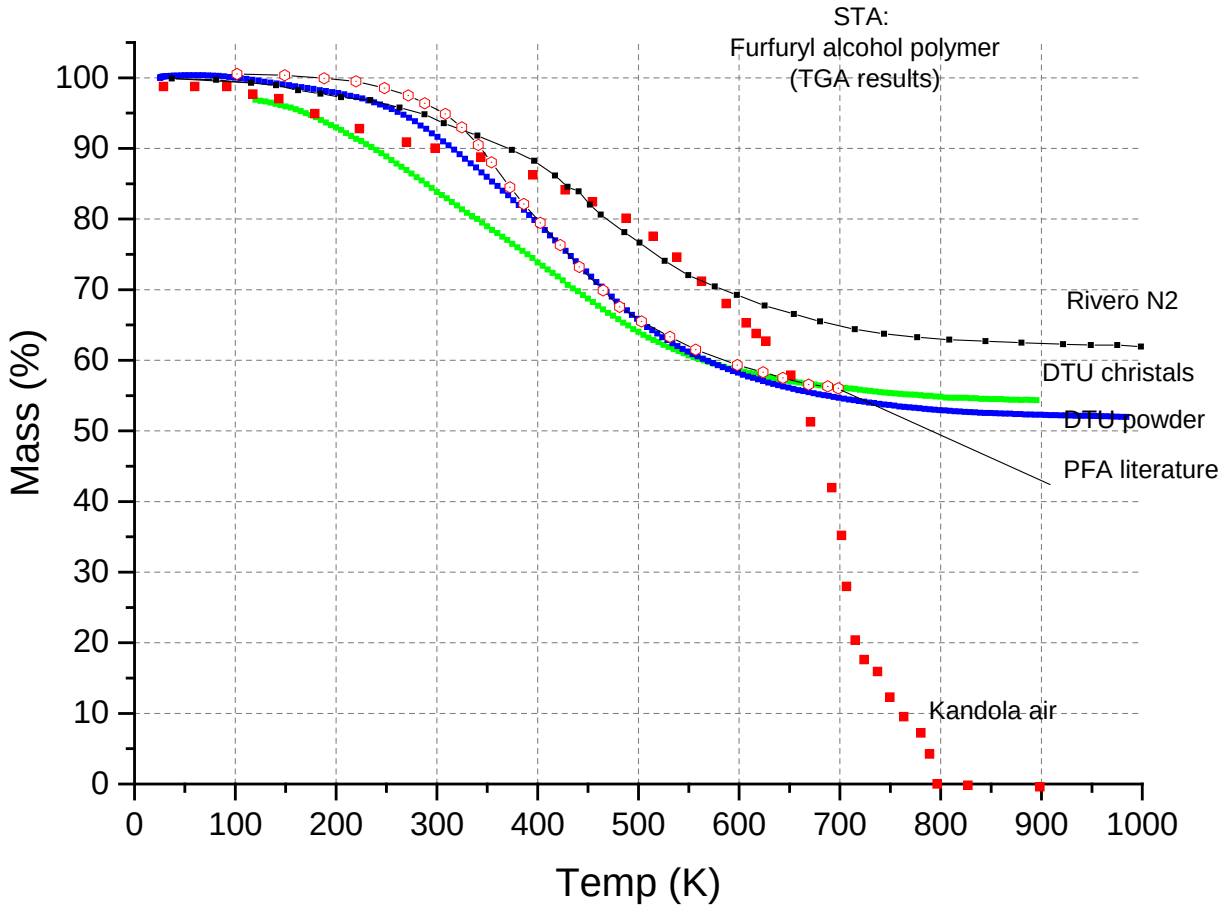
- Both, the glass fiber furan and the hemp fiber furan composites were found to be difficult to ignite
- The furfuryl alcohol resin burns away leaving intact woven mat.

TGA of furan hemp composite





TGA results for PFA



Rivero furfural –phenolic co-polymer

Kandola, B. & Krishnan, L., 2014. Fire performance evaluation of different resins for potential application in fire resistant structural marine composites. Fire Safety Science, 11, pp.769–780.

PFA –lit: Guadalupe Rivero, Sara Villanueva, L.B.M., 2014. Furan resin as a replacement of phenolics: influence of the clay addition on its thermal degradation and fire behaviour. Fire and Materials, 38, pp.683–694.

conclusions

- Hemp and glassfibre PFA composites are investigated using TGA
- PFA degrades at high temperatures and has high residue yield
  - Black crystaline powder
- Degradation under oxidizing conditions are faster less residue yields
- Better performance compared to cellulose
- Co-polymerization as in PFA-phenolic resin may give improvements

THAT's ALL FOR NOW

THANK YOU

QUESTIONS ?

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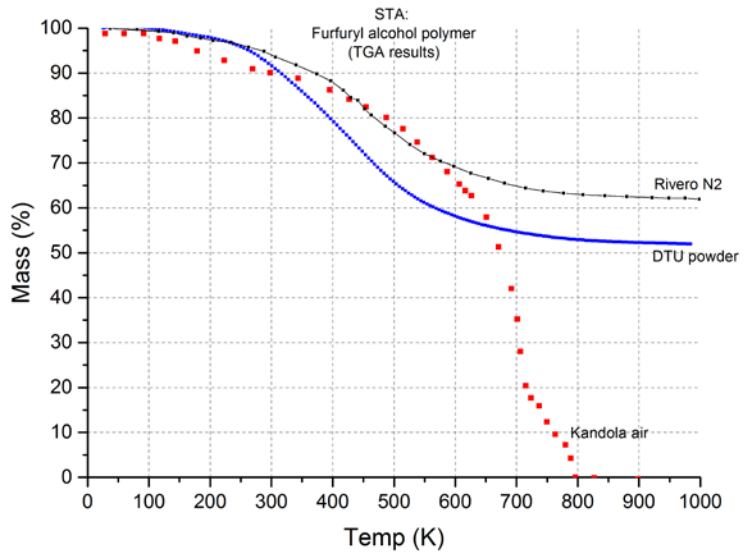
abstract

Composites made of glass or hemp fibers and furfuryl-alcohol are an alternative for fossil fuel based conventional materials [1]–[3]. Such composites have excellent strength and furfuryl alcohol is manufactured from agricultural residues [4]. In general, many different sustainable bio-composites are developed in many different areas as they are seen as excellent alternatives to conventional materials with regard to their weight-strength ratio. Nevertheless, biomaterials are combustible and therefore their application depends on the actual fire performance of these compounds. These have to follow the fire safety regulations. The paper is investigating the reaction to fire for two composites using a resin of furfuryl alcohol and glass fibers as well as hemp fibers. The composites are made at DTU wind energy using vacuum compression moulding and are tested for their mechanical strength. The samples used for the fire tests had been stored for some years under ambient conditions inside a laboratory environment. Different methods are used to investigate the reaction to fire: Vertical upward flame spread; Bomb calorimeter, Mass loss cone calorimeter, STA tests under inert atmosphere.

Both, the glass fiber furan and the hemp fiber furan composites were found to be difficult to ignite, as no ignition occurred in the flame spread tests using a normal lighter. It needed a gas burner to ignite the samples. The flame spread was moderate, but no self-extinction occurred in the case of glass fiber furan composite. This is also reflected by the preliminary results of the STA analysis showing that the degradation under nitrogen atmosphere is giving a residue of above 50% of the sample mass both for a literature example measured by Rivero et al [5]and by DTU. Changing the atmosphere to air the main combustion is taking place at about 700 K leading to complete degradation [6].



The findings will be more detailed presented and it will be argued about the benefits and constraints using these types of composites in applications, as e.g. as materials for wind mills or marine applications.

References

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[6] B. Kandola and L. Krishnan, “Fire performance evaluation of different resins for potential application in fire resistant structural marine composites,” *Fire Saf. Sci.*, vol. 11, pp. 769–780, 2014.